Brains, drains, and roads, growth hills: complementarity between public education and infrastructure in a half-century panel of states

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Brains, drains, and roads: Growth hills and complementarity for public infrastructure and education in a half-century panel of states

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Abstract

Applying a Barro-style model of endogenous growth to a fifty-year panel of states from 1957 to 2007, We examine the extent to which expenditures on public education and infrastructure—*together with the taxes necessary to support them*— enhance or impede the steady-state growth of state and local economies, as measured by per capita personal income. Our findings suggest that the independent effect of tax expenditures on either public infrastructure or education *alone* is significantly *negative*, but the complementary effect of each on the other is positive enough to make their combined effect significantly positive— except at large scales, where we find diseconomies, consistent with the 'growth hill' predicted by theory. Policy effects are identified empirically using a recursive structure with very long lags, GMM/instrumental variables, and controls for both fixed and time-varying heterogeneity. Results are robust to a variety of alternative specifications.

Introduction

Eco*nomic crisis, public infrastructure and education*

The economic crisis of 2008-2009 brought to the forefront the political and economic question of whether public expenditures on education or infrastructure stimulate economic growth – either in the short-term, cyclical sense, or in the steady state. Applying empirical specifications of a Barro (1990)-style model of endogenous growth to a fifty-year panel of states from 1957 to 2007, we examine the extent to which expenditures on public infrastructure and education– together with the taxes necessary to support them—enhance or impede the growth of state and local economies, as measured by per capita personal income. We are particularly interested in the possible complementarity between public investments in human capital and other public infrastructure.

Distinction from prior studies

Prior studies (e.g. Cohen and Paul (2004), Evans and Karras (1994), Duffy-Deno and Eberts (1991), and Pereira (2000), are typically based on a regional production function, and often find significantly positive effects separately for education or public infrastructure.[1] Our findings suggest that the independent effect of tax expenditures on either public education or infrastructure *alone* is significantly *negative*, but the complementary effect of each on the other is positive enough to make their total effect significantly positive— except at large scales, where we find the diseconomies predicted by theory. Our findings are consistent with the agglomeration-type economies found by Cohen and Paul (2004), the complementarities among

[1] Evans and Karras (1994) find either insignificant or negative effects for public infrastructure, and positive effects only for education. Distinguishing between infrastructure maintenance and new investment, Kalaitzidakis, *et. al.* (2005) find positive effects on Canadian growth for expenditures for maintenance of public infrastructure, but in this case, one might worry about spurious pro-cyclical correlations between maintenance expenditures and economic growth.

various forms of both public and private capital found by Pereira (2000)—as well as the complementarity between education and *institutional* infrastructure found by Hanushek (2007) for a panel of developing countries. Even so, our study is distinguished from these and other prior studies by four key features:

Opportunity cost

First, unlike production function based studies, we account explicitly for the *opportunity cost* of increased tax expenditures on public education or infrastructure via an explicit model of endogenous growth and a fully specified government budget constraint; A number of studies, notably including the important work on cities by Edward Glaeser, *e.g.* Glaeser *et. al.* (2000) find for example, that higher initial levels of education are related to higher subsequent growth, but one cannot conclude from this that higher tax expenditures on public education will have similar results, in part because one does not know the opportunity cost. Indeed, Glaeser *et. al.* (2000) find that the *only* government expenditure category correlated with *city* growth is *sanitation.* (Here, we estimate growth effects of state and local expenditures on public infrastructure and education, *while accounting for the opportunity cost* (in terms of growth) of the corresponding taxes. By fully specifying the budget constraint, one can gauge the opportunity cost of a change in any element of the budget, net of the effect of a compensating change in any other element. Helms (1985), Barro (1989), and Mofidi-Stone (1990).

Identification of policy effects

Second, the fifty years of panel data enable us to identify the steady-state effects of public education and infrastructure on growth using a recursive structure, very long, generation-length lags, GMM instrumental variables, and controls for both time-varying and fixed effects to account for unobserved heterogeneity across both states and periods. This approach mitigates issues of endogeneity and spurious correlation that plague studies of the effects of regional fiscal policies:

Explicit model of endogenous growth

Third, our empirical specifications are drawn from an explicit model of endogenous growth: In the Barro (1990) model, tax expenditures on productive infrastructure and other activities increase steady-state growth as long as the complementarity between private capital and public infrastructure is sufficient to raise the after-tax return to private capital above the private rate of time preference.

Growth hills and complementarity

Fourth, we focus on an *additional* source of possible complementarity: between public infrastructure and education. We focus as well on a related phenomenon predicted in the Barro model: The marginal effect of taxes exhibits a 'growth hill'— that is, positive when the negative effect of an increase in initially low taxes is more than offset by the positive effects of increased expenditures on (scarce) productive public goods, but eventually negative when (high) taxes are raised even higher to spend on (now more abundant) productive public goods; (the effect passes through zero in between). We find unique evidence for just this kind of growth hill.

Theoretical background

Unlike the neoclassical growth model, where fiscal effects alter the *level* of the long-run output path, the Barro endogenous growth model permits fiscal effects to alter the *slope* of the long-run output path, as illustrated for example in Barro (1990). The key to endogenous growth in the Barro model is complementarities between private capital and publicly provided 'productive' goods, expressed in the following way: There are n producers, each producing output (y) according to the production function:

$$y = Ak^{(1-a)}g^{a} \quad (1)$$

where A is a positive constant, k is private capital, g is a publicly provided input complementary to private capital, and a is between 0 and 1. The government funds its budget with a proportional tax on output at the rate r. The balanced-budget government budget constraint is therefore:

$$n\, g + C = r\, ny \quad (2)$$

Where C is government-provided consumption, i.e. 'non-productive' goods.[2]

Private capital is endogenously determined in the Barro model, hence is not an independent variable determining growth. Thus, output growth in the steady state depends on (unobserved) parameters in production and utility), the tax rate (r), and the ratio of expenditures on public inputs to output (g/ny). One may then use eq. (2), the government budget constraint to substitute for the tax rate r, which leaves all other budget elements in the equation for growth except taxes, so that the effect of a change in any one budget element is measured against the effect of a compensating change in taxes. Of course, one could substitute for any other budget element instead, but in the present case, use of a corresponding change in taxes yields estimates of the effects of changes in other budget elements *net* of the opportunity cost of the effect of a compensating change in taxes. This approach is then typically used to motivate a static or dynamic *linear* empirical equation, as in Barro (1989), or Bleaney, Gemmell, and Kneller (2001,1999). Here, we focus first, on isolating the possibly complementary effects of public education and infrastructure, and then incorporate closely related issues of Barro's nonlinear growth hill. Complementarities between public and private capital and among types of public capital are illustrated by the following adaptation of eq. (1):

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[2] Alternatively, one could also incorporate a deficit (or surplus). Doing so offers little gain in the context of U.S. states. For U.S. states, deficits and surpluses are typically small, less than one percent of personal income, so for simplicity we abstract from a non-zero deficit or surplus. However, we include the deficit/surplus as one of several auxiliary control variables, and results are not sensitive to whether or not it is included.

$$y = Ak^{1-a_1-a_2} g_1^{a_1} g_2^{a_2} \tag{1b}$$

where g_1 and g_2 represent expenditures (as a % of output) on public infrastructure and education, respectively. As before, k represents private capital, which is endogenously determined. Equation (1b) maintains Barro's central assumption of constant returns to scale for private and all types of public capital together.[3]

Spatial equilibrium with common pools of capital and labor

Growth arises endogenously in the Barro model as private capital accumulates via savings. In the context of the U.S, one might argue, as in Glaeser *et. al.* (2000), that regions share common pools of both capital and labor. If so, increases in private capital can arise not only from regional savings but also from inflows of capital if the net return to capital rises above that of other regions; and labor can also flow from one region to another in response to shifts in both wages and what Glaeser *et. al*. (2000) call "quality of life'—which declines with population, as positive amenities are congested, disamenities rise, and local land rents are driven up.—as in Roback (2007), The interplay between quality of life and land rents on the one hand and productivity on the other yields a spatial equilibrium in which equilibrium wages and per capita incomes can differ across regions, even in the absence of costs to spatial movements by firms or workers. Here, we are concerned primarily with effects on steady-state growth of *per capita* income, not with disentangling the separate dynamics of income and population growth, which interact to determine growth of per capita income. (In any event, our estimates are insensitive to whether a variable for population growth is included).

Data and empirical specifications

[3] Romer (1987) and others have argued that education and knowledge might be a source of increasing returns through influence on *A*, the technology parameter. We do not propose a test of that hypothesis here.

Our dependent variable is GROWTH, the (log %) growth in real personal income per capita in each state. The key fiscal variables are TAXES, the ratio of all state and local taxes to state personal income. Again, TAXES also becomes the reference variable when it is replaced by the remainder of the government budget constraint, and eliminated from the estimated equation. Thus, the effect of a change in any element of the budget constraint is estimated net of the effect of a compensating change in taxes. Other fiscal variables are: FEES, the ratio of state and local fees to personal income; FED, the ratio of federal governmental transfers to personal income; EDUC, the proportion of personal income devoted to public expenditures on education (both higher education and k-12); PROD, the proportion of personal income devoted to public expenditures on all 'non-consumption" goods, i.e. excluding EDUC; we refer to PROD here as 'infrastructure,' both physical and 'institutional, *e.g*. public safety and judicial systems;[4] OTHER, which primarily represents public transfer-payment, health, welfare, and other entitlement programs; and finally, SURPLUS represents any budget surplus, expressed as a proportion of personal income (negative if a deficit).[5] Also, we find, as in Gray, et. al. (2006), that fixed effects for both state and period heterogeneity are important, so all specifications include fixed effects for both state and period. In addition, we include lagged GROWTH to account also for unobserved time-varying (or state-dependent) heterogeneity.

Our data for state fiscal variables are from the Census of Governments at five-year intervals from 1957 through 2007;from the Bureau of Labor Statistics (for the state unemployment rate);and from the Department of Commerce (for state real personal income per

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[4] Consistent with the complementarity Hanushek and Woessman (2007) find for education and institutional infrastructure, we include expenditures on both physical and institutional infrastructure in PROD.

[5] Also, consistent with other studies (*e.g.*, Helms 1985 and Mofidi-Stone 1990), we treat UI expenditures as outside the regular fiscal structure, in part because UI is largely driven federally, with separate accounting. A surplus (or deficit) is included as an auxiliary control, as noted above, and results are insensitive to inclusion or exclusion.

capita.) We exclude Alaska as an exceptional outlier due to the idiosyncratic dominance of the Alaska pipeline and extreme variance in its state fiscal variables relative to the other 49 states.

Thus, for most variables we have data for 49 states at five-year intervals from 1957 to 2007. Table1 presents summary statistics for the dependent and explanatory variables. The average value for GROWTH for the *five-year* data interval is approximately 12.1 %, roughly 2.4% per annum. The average value for TAXES is about 9.9%, with average values of 3.5% for OTHER, 7.4% for PROD, 6.4% for EDUC, 3.6% for FED, and 5.9% for UR.

Dynamics and identification.

We take the following approach in specifying the dynamics for growth. First, we assume *a priori* that the current five-year growth rate is not significantly affected by contemporaneous fiscal variables, but is a function of the fiscal variables from previous periods. Thus, for example, real personal income growth per capita between 1962 and 1967 is unaffected by *contemporaneous* values of fiscal variables. Mofidi and Stone (1990) successfully employ this recursive approach for five-year data for states. Eberts and Stone (1992) and Mark *et al*. (2000) employ a similar recursive strategy with annual data – the former for major U.S. metropolitan areas, and the latter for jurisdictions in the District of Columbia metropolitan area. In addition, Glaeser *et. al*. (2000) and Bleaney *et. al. (1991,* 2001) employ recursive structures for a panel of OECD countries. Our base specification has 25-year lags, *i.e.* we first use average values over the previous 25 years. For education, this generation-length lag incorporates a full cohort of kindergarten through college students, as well as 'time-to-build' factors in education. We find similar results, however, if shorter lags are also incorporated, or used instead. Use of such long lags in a recursive structure substantially mitigates issues of endogeneity and spurious correlations arising from short-term, cyclical factors. Even so, we further mitigate these by including the state unemployment rate,[6] both state and period fixed effects, and a lagged dependent variable to account also for time-varying, or state-dependent heterogeneity, which might otherwise yield spurious correlations between growth and the lagged fiscal variables. We use instrumental-variable techniques and generalized method- of-moments (GMM) estimators to account for the inconsistency of dynamic fixed-effects models in samples with a finite number of time periods. In our case, the number of periods is well below the number of states included, so the Arellano-Bond (1991) and Arellano-Bover (1995) style GMM estimators are appropriate. These GMM estimators use lagged values of the dependent variable and exogenous (or predetermined) regressors as instruments.

Regression & GMM Results

Tables 2a and 2b present regression and GMM instrumental- variable estimates, respectively—where the number of discrete five-year interval lags follow in parenthesis and any other number following a variable indicates the number of prior years over which the lagged value of a variable is averaged. Again, our dependent variable is GROWTH, the log-change in state real personal income per capita (times 100). the fiscal variable omitted from the estimated equation in Tables 2a-2b is (TAXES plus FEES), the ratio of state and local taxes and fees to personal income (times 100), so that changes in expenditures for any fiscal category are implicitly financed by taxes and/or fees.

Again, the estimates in Tables 2a-2b include fixed effects for period and state, as well as time-varying effects captured by lagged GROWTH.[7] Robust (panel-corrected) standard errors are presented. The coefficients for lagged education expenditures (EDUC25) and lagged

[6] The unemployment rate is a particularly good control for primarily cyclical or short-term, idiosyncratic influences because it tends to be strongly mean reverting, *i.e.* tends to exhibit exhibits long-run stationarity.
[7] Inclusion or exclusion of lagged growth has little effect on the estimates.

expenditures on public infrastructure (PROD25) are both significantly *negative*, but their complementary effect, the coefficient for (EDUC25*PROD25) is significantly *positive*. The combined impact of the direct and complementary effects is also significantly positive for both EDUC25 and PROD25, evaluated at sample means. The growth effect of tax expenditures on welfare, transfer-payment and other entitlement programs, (*i.e.*, OTHER 25, is significantly negative. And the coefficient for federal transfers (FED25) is significantly positive. The GMM and OLS estimates yield roughly similar coefficients, and The J statistic in Table 2b for a test of the over-identifying GMM restrictions fails to reject them.

Growth hills and complementarity for education and infrastructure

Due to the collinearity of the elements of the government budget constraint, one cannot estimate the growth hill for taxes predicted by the Barro model in a straightforward way while *simultaneously* estimating the effects of tax-financed expenditures on education and infrastructure. To do this, the empirical specification must be modified to include taxes, education *and* infrastructure, as well as all other elements of the government budget constraint. Doing so is impossible over strictly the same time period, since the elements of the balanced budget constraint are perfectly collinear. We circumvent this problem by exploiting the length of our data to identify two different time horizons, which is feasible if the lagged effects are insensitive to the differences in length of lag, which appears to be the case. First, as in Tables 2a-2b, we focus on 25-year lags for EDUC and PROD, and second, on shorter, (five-year) lags for taxes and all other elements of the government budget constraint *except* education and infrastructure. Thus, we are able to estimate the effect of tax expenditures, lagged five years, *which are implicitly spent on education and infrastructure during that period.*

We specify the growth hill for taxes as a quadratic, with an (expected) positive linear term and negative quadratic term, respectively. Tables 3a and 3b present OLS and GMM estimates, respectively. Despite the changes in specification, estimates for education and infrastructure are reassuringly similar to those in Tables 2a-2b, indicating that estimates are not highly sensitive to length of lag. The J-statistic again fails to reject the over-identifying GMM restrictions, and the tax coefficients do, in fact, exhibit a growth hill, with a positive linear effect and negative quadratic effect, as predicted. That is, growth initially rises with tax expenditures on EDUC and PROD (which jointly are the omitted fiscal category in Tables 3a-3b), reaches a peak (near the sample mean for taxes), and then declines. Indeed the marginal effect of tax expenditures is significantly negative at the upper range of current state taxes, (*e.g.* New York and Massachusetts). This *estimated* growth hill is illustrated in Figure 1 for both in- and out-of-sample ranges of taxes. The outer portions of the upward and downward sloping segments differ significantly from both zero and the peak of the growth hill.

More on Growth hills and complementarity

The scale diseconomies for tax expenditures predicted by the Barro model and evident in Tables 3a-3b can also be seen in Tables 4a-4b, which include a quadratic term for the *interaction* between education and infrastructure. The interaction is initially significantly positive as before, but the quadratic interaction term in Tables 4a-4b for the scale of expenditures (and implicitly taxes) is negative .

Thus, the growth hill found explicitly for taxes in Tables 3a-3b is evident explicitly for education and infrastructure as well . (in Tables 4a-4b)

Three primary forces interact in the Barro model to determine the shape of the growth hill): 1) taxes tend to depress the *net* return to capital, But 2) tax-financed public investments are complementary with private capital, tending to raise the return to private capital, yet 3) Individually, both public and private capital are subject to diminishing marginal returns, even though together, they exhibit constant returns to scale.

All three factors are identified in our empirical results, but we also identify a *fourth* factor introduced by our adaptation of the Barro model: The complementarity between public infrastructure and education.

The various factors at play in the nonlinear growth-hill patterns, including those illustrated in Figure 1, are *theoretically* consistent with our adaptation of the Barro model, but need ***not** all* be found simultaneously in the data, so, the estimates appear to be particularly robust evidence of the interrelated factors at play in the growth-hill phenomenon.[8]

Alternative specifications and robustness tests

Estimates for the effects of education and infrastructure on growth are insensitive to a variety of alternative specifications, including alternative lag structures, inclusion of short-term cyclical variables such as the unemployment rate, controls for time-varying heterogeneity via a lagged dependent variable, or to GMM instrumental-variable techniques. Estimates are also insensitive to the inclusion of lagged five -year population growth, suggesting that growth effects of public investments in education and infrastructure do not work primarily through changes in population.

[8] The estimates are also consistent with the local 'revenue hills' found for cities by Haughwout, *et. al.* (2004)

Concluding remarks.

Complementarity between private and public capital lies at the core of the Barro model of endogenous growth. In this paper we explore an *additional* source of complementarity: between public infrastructure and education. The independent effect of expenditures on either *alone*, net of the effects of the taxes necessary to support them, appears to be negative for growth in per capita income. However, the complementarity between public infrastructure and education is positive enough for the total effect of either to be significantly positive, except at large scales, where we find significant diseconomies. Taken at face value, our findings suggest that such complementarities make 'coordinated' public investments in "brains, drains and roads" a superior strategy at the state and local level. Our positive findings for investments in public education appear to run counter to other recent arguments—put forth prominently by Eric Hanushek (2007) and others that "resources "do not matter" in education.[9] Indeed, effects of incremental investments in either public infrastructure or education on growth appear to be significantly positive at current levels of those investments. In subsequent work, it would be useful to investigate in greater detail the nature of the complementarity between education and public infrastructure, as well as perhaps, potential differences between k-12 and postsecondary education. It would also be helpful to have more precise estimates of the various 'threshold points' for the scale economies and diseconomies ('growth hills' identified in Tables 3a-3b and 4a-4b).

[9] Brewer (1997) provides a review of evidence for this argument, along with a critique based on the role of unobserved heterogeneities in obscuring the role of resources. Evidence here for investments in public education, along with complementary investments in public infrastructure is consistent with the view that resources can matter.

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Table 1. (49 States 1957-2007)

Variable Means

Variable	Mean
GROWTH	12.1
EDUC	6.4
PROD	13.9
OTHER	3.5
SURPLUS	0.1
TAXES	9.9
FEES	3.7
FED	3.4
UR	5.9

Notes: see text for sources and explanation of data and variables.

Table2a. OLS : Growth Effects of Tax Expenditures on Education and Infrastructure (49 States 1957-2007)

Variable	Coefficient	Robust std Error	t-Statistic	Prob.
C	83.36792*	20.81769	4.004668	0.0001
GROWTH-1	- 0.114941*	0.053714	-2.13987	0.0334
EDUC25	-11.4112*	3.016751	-3.78261	0.0002
PROD25	-3.111116	1.603839	-1.93979	0.0536
EDUC25*PROD25	0.684651*	0.180865	3.78542	0.0002
OTHER25	-2.137347	1.275286	-1.67598	0.0951
FED25	1.235495*	1.375335	0.898323	0.3699
UR	- 2.386857*	0.214894	-11.1071	0

Effects pecification
Cross-section fixed
dummy variables)
Period fixed
(dummy variables)
Dependent Variable: GROWTH

R-squared	0.604952		
Adjusted R-squared	0.50322	S.D. dependent var	4.7134
S.E. of regression	3.32202	Akaike info cr**iterion**	5.4215
Sum squared resid	2571.4	Schwarz criterion	6.1857
Log likelihood	-735.10		
nobs	294		

*sig @5%, robust PeriodSUR std errors)
See text for data and variables

Table2b . GMM: Growth Effects of Tax Expenditures on Education and Infrastructure

(49 States 1957-2007)

Variable	Coefficient	robust Std. Error	t-Statistic	Prob.
GROWTH-1	0.176748*	0.071614	2.467919	0.0143
EDUC25	-10.171*	2.723781	-3.73439	0.0002
PROD25	-2.71524*	1.262222	-2.15116	0.0325
EDUC25*PROD25	0.62626*	0.156468	4.002431	0.0001
OTHER25	-1.7334*	0.751326	-2.30708	0.0219
FED25	0.85801	1.068592	0.80293	0.4228
UR	-2.2381*	0.199281	-11.1782	0
Effects Specification				
Cross-section fixed (orthogonal deviations)				
Period fixed (dummy variables)				
Dependent Variable: GROWTH				
R-squared 0.472771				
Adjusted R-squared	0.4479	S.D. dependent var		4.8795
S.E. of regression	3.62571	Sum squared resid		3063
J-statistic	15.9945	Instrument rank		21
no. observations	245			

* sig @5%, robust, White Period std errors

See text for data and variables

Table 3a. (OLS)Growth hills and tax expenditures on education and infrastructure
(49 States, 1957-2007)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	45.10316*	21.83251	2.065871	0.04
GROWTH (-1)	-0.13312	0.055033	-2.418918	0.0163
EDUC25		2.875417	-2.852117	0.0047
PROD25	-1.949309	1.441387	-1.352384	0.1776
EDUC25*PROD25	0.478536*	0.17577	2.722511	0.007
TAXES(-1)	3.990071	2.07161	1.926072	0.0553
TAXES(-1)^2	-0.2035	0.087659	-2.321507	0.0211
OTHER25	-2.532344	1.096552	-2.309369	0.0218
FED(-1)	1.44332	0.656361	2.198973	0.0289
UR	-2.170226	0.205564	-10.55742	0

Effects Specification
Cross-section fixed (dummy variables)
Period fixed (dummy variables)
Dependent Variable: GROWTH

R-squared	0.637693	S.D. dependent var	4.713261
Adjusted R-squared	0.54045	Akaike info criterion	5.348538
S.E. of regression	3.195124		
Sum squared resid	2358.236		
Log likelihood	-723.235		
nobs	294		

* sig @5%, robust, White Period std errors
See text for data and variables

Table 3b . (GMM) Growth Hills and Tax Expenditures on education and infrastructure

(49 States 1957-2007)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GROWTH-1	0.322531*	0.162104	1.989657	0.0478
EDUC25	-14.39457	4.650246	-3.095444	0.0022
PROD25	-3.256282	1.456721	-2.235351	0.0264
EDUC25*PROD25	0.794311*	0.231573	3.430064	0.0007
TAXES-1	15.04109	6.794626	2.213675	0.0278
TAXES-1^2	-0.571242	0.274635	-2.080007	0.0386
OTHER25	-2.596186	2.277082	-1.140138	0.2554
FED-1	0.90145*	2.577435	0.349762	0.7268
UR	-2.400*	0.268735	-8.93047	0

Effects Specification

Cross-section fixed (orthogonal deviations)
Period fixed (dummy variables)
Dependent Variable: GROWTH

R-squared	0.339052	Mean dependent var	0.783551
Adjusted R-squared	0.301856	S.D. dependent var	4.87951
S.E. of regression	4.077074	Sum squared resid	3839.805
J-statistic	14.42138	Instrument rank	21
Nobs	245		

* sig @5%, robust, White Period std errors

See text for data and variables

Table4a . (OLS) Scale Diseconomies

(49 states, 1957- 2007)

Variable	Coefficient	robust Std. Error	t-Statistic	Prob.
C	51.12215*	18.59316	2.749514	0.0063
GROWTH-1	-0.225054*	0.064641	-3.481618	0.0006
EDUC-1	-7.430106*	3.513807	-2.114546	0.0351
PROD(-1)	-3.400008*	1.5249	-2.22966	0.0264
EDUC(-1)*PROD(-1)	0.666105*	0.306212	2.175306	0.0302
(EDUC(-1)*PROD(-1))^2	-0.00077*	0.000366	-2.101604	0.0363
FED(-1)	3.222522*	0.618192	5.212815	0
OTHER(-1)	-2.089325*	0.504887	-4.138207	0
UR(-1)	0.099116	0.276015	0.359094	0.7197

Effects Specification

Cross-section fixed (dummy variables)
Period fixed (dummy variables)

Dependent Variable:	GROWTH			
R-squared	0.479798			
Adjusted R-squared	0.391252	S.D. dependent var	5.508888	
S.E. of regression		4.29816	Akaike info criterion	5.88958
Sum squared resid		6946.292	Schwarz criterion	6.492274
Log likelihood	-1233.652	F-statistic	5.418679	
no. observations	441			

*significant at .05
Note See text for explanation of data and variables standard errors are PCSE, Period SUR

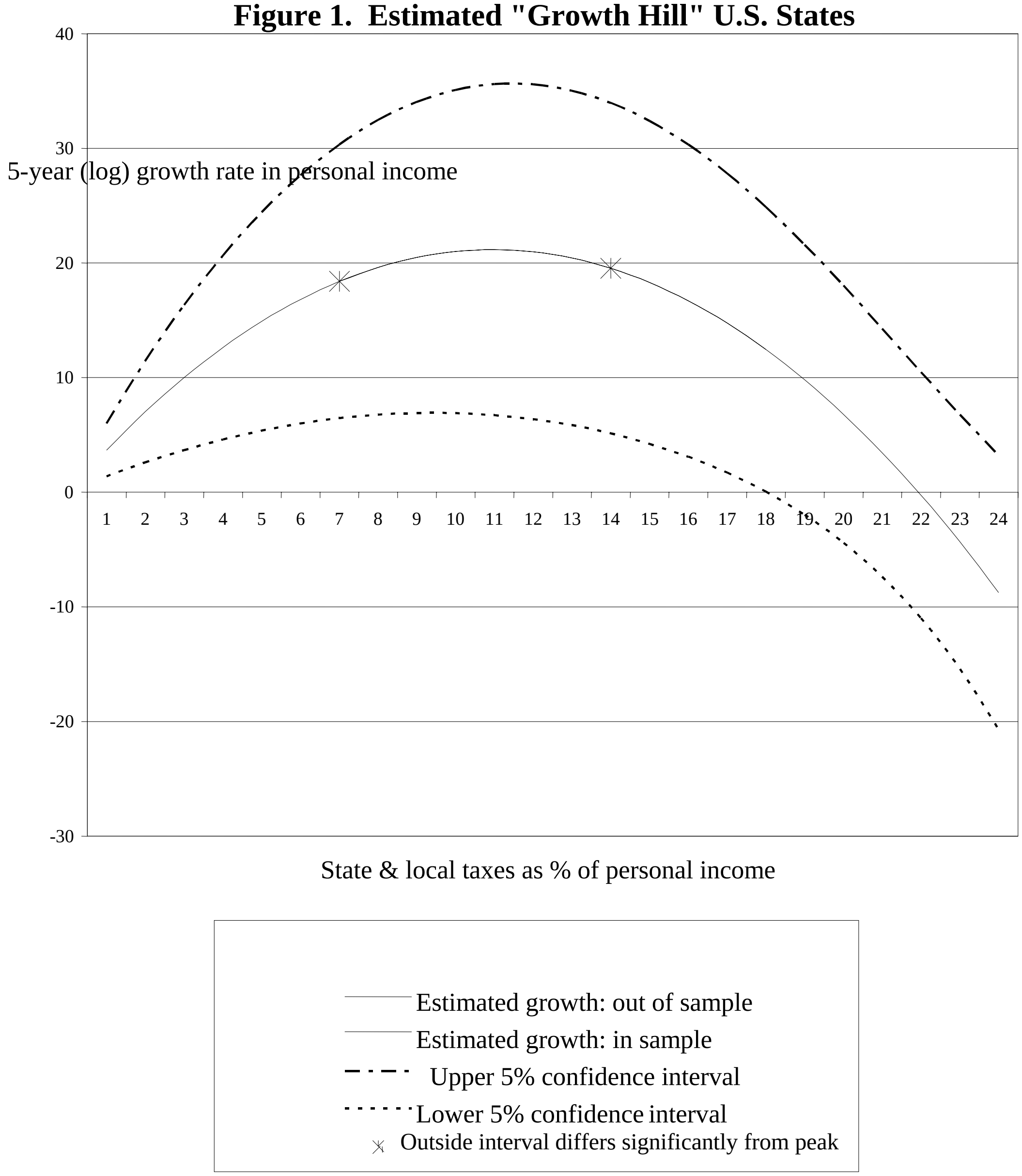
Table4b. (GMM) Scale Diseconomies
(49 States, 1957-2007)

Variable	Coefficient	robust Std. Error	t-Statistic	Prob.
GROWTH (-1)	0.053955	0.091485	0.589776	0.5557
EDUC(-1)	-7.757809*	1.984921	-3.908372	0.0001
PROD(-1)	-3.42985*	0.837822	-4.093768	0.0001
EDUC(-1)*PROD(-1)	0.721885*	0.166484	4.336056	0
(EDUC(-1)*PROD(-1))^2	-0.000806*	0.000199	-4.044571	0.0001
OTHER(-1)	-1.771894*	0.467081	-3.793544	0.0002
FED(-1)	2.524942*	0.545215	4.631097	0
UR	0.44927*	0.179876	2.497669	0.0129

Cross-section fixed (orthogonal deviations)			
Period fixed (dummy variables)			
Dependent Variable:	GROWTH		
		S.D. dependent var	5.31545
Adjusted R-squared	0.297224	Sum squared resid	7465.9393
S.E. of regression	4.456032	Instrument rank	28
J-statistic	23.76		
Nobs	392		

*sig@.5% See text for data and variables. (robust, (White period std. errors)

Figure 1. Estimated "Growth Hill" U.S. States



Notes: See text for explanation of estimates, data, and variables.